Luminescence Properties of Er implanted n-GaN

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Erbium (Er) -doped semiconductor is a potentially useful material for light-emitting devices in optical communication systems, since the intra-4*f*-shell transitions of Er ions cause sharp and temperature-stable luminescence in various host materials at 1.54 μm, which corresponds to the minimum absorption of silica-based optical fibers. Photoluminescence (PL) from Er^{3+} in Er-doped narrow band gap semiconductors (e.g. silicon) is a weak and difficult to observe at room temperature (R.T). Gallium nitride (GaN) is a useful host material because it equips the wide band gap and improves the luminescence properties of the Er^{3+} ions. In this work, we implanted Er into undoped epitaxial GaN layer grown on sapphire substrate (GaN:Er) and studied the luminescence properties of Er^{3+} ions on annealing temperature, Er dose and temperature dependencies for three kind of atmosphere.

Er implantation energy was performed at 400 keV with a dose range from 3 x 10^{13} cm^{-2} to 2 x 10^{15} cm^{-2} at R.T. Following the ion implantation, these samples were annealed at ranging from 1000 ℃ to 1200 ℃ for 30 minutes using a rapid thermal annealing.

Fig.1 shows the Er^{3+}-related PL spectra of GaN:Er for different Er doses at 15K. Several peaks were observed at around 1.5 μm, and the dominant peak is located at 1537.8nm. The PL intensity of the dominant peak increased with increasing Er dose from 3 x 10^{13} cm^{-2} to 1 x 10^{15} cm^{-2}. In the sample, when Er was implanted into the GaN:Er with a dose of 1 x 10^{15} cm^{-2} the PL intensity of the dominant peak was maximum. Fig.2 shows the Er^{3+}-related PL spectra of GaN:Er for different atmosphere. The PL intensity of the dominant peak at 1537.8nm was strongest in atmosphere NH_3:N_2 (1:9). Fig.3 shows the temperature dependence of the Er^{3+}-relateed PL intensity. It is clear that there are some thermal quenching processes on these grounds, we conclude that Er^{3+} forms some complex centers with N in GaN:Er and that at least two complex centers contribute to the luminescence of GaN:Er .

By investigating the temperature dependence of the Er^{3+}-related PL intensity, we found that thermal quenching of the luminescence of Er^{3+} was suppressed by using GaN as a host material instead of Si, and that Er^{3+} forms at least two Er-N complex centers with N which contribute to the luminescence of Er^{3+} in GaN:Er .

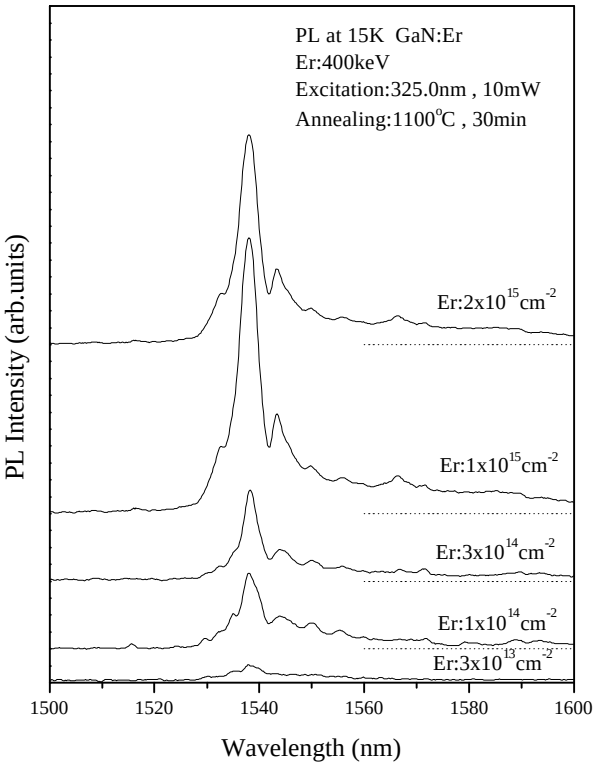

Fig.1. The Er^{3+}-related PL spectra of GaN:Er for different erbium dose.

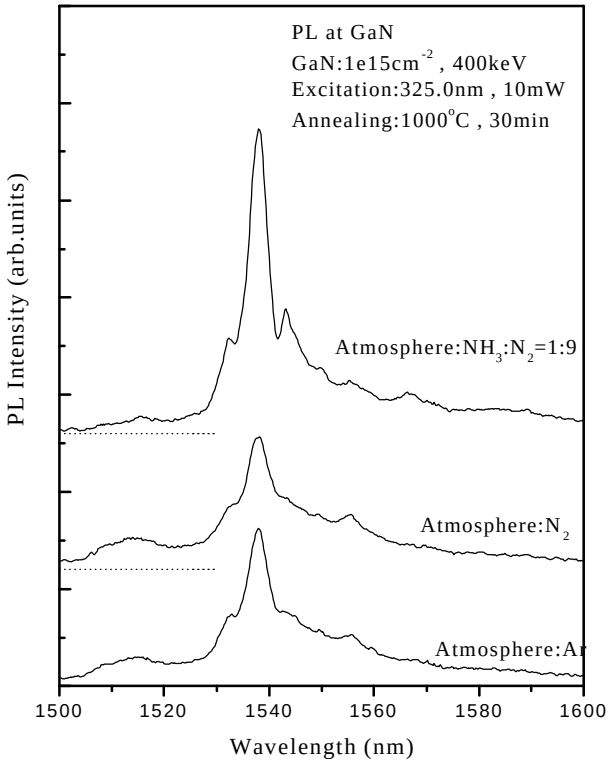

Fig.2. The Er^{3+}-related PL spectra of GaN:Er (Er:1 x 10^{15} cm^{-2}) for different atmosphere.

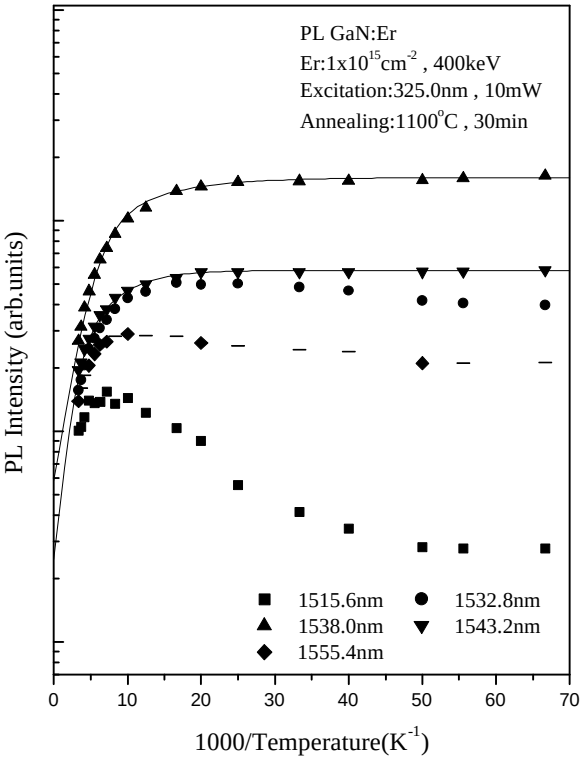

Fig.3. Temperature dependece of PL intensity in GaN:Er annealing at 1100℃

Reference
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